U.S. Navy Laboratory Topics

TOPIC: OSD95-010 TITLE:Dental Conduction Hearing for Divers

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TECHNOLOGY: Sensors, Materials and Structures, Human-System Interfaces

OBJECTIVE: Develop technology to permit hearing via bone conduction through the teeth using a low voltage transducer built into a scuba mouthpiece.

DESCRIPTION: The objective is based on materials technology conceived and developed by the Government and spun off to the civilian sector. The rare earth magnetostrictive material, Terfenol-D, developed by the Navy, permits high power transduction with very low voltage and thus a safe system for installation inside the mouth. Audiodontics, Inc. (located in Bethesda, MD and willing to license) and the University of Maryland Dental School have developed a bone conduction hearing aid using a very small Terfenol transducer which attaches to a tooth and transmits vibrations from a wireless hearing aid. The hearing aid was developed for people who cannot use normal hearing aids because of infections or bone growth. Vibrating the tooth accomplishes hearing via bone conduction. The transducer is excited by a small receiver fitted to a retainer on the wearer's palate. Signals are transmitted to this device from a shirtpocket-mounted hearing aid. This is a significant advance in this hearing technology in that it eliminates the need for a traditional bone contact transducer behind the ear which encourages skin abrasion and subsequent infection.

The civilian and military diving communities utilize diver communication systems which use ordinary earphone technology to permit a diver to hear instructions, commands, or sonar system output. This necessitates special head gear to allow the wearing of air-conduction earphones. In the specific case of divers using a diver-held mine-hunting/detection system, the earphones used to hear sonar echoes are far from comfortable and effective. The initial approach to adapting this technology to the problem is to design and develop a transducer immersed in the diver's mouthpiece which will permit coupling of sound from the mouthpiece into the teeth of the diver. An air path will be unnecessary.

Phase I. The contractor will design and fabricate a prototype transducer mounted in a scuba diver mouthpiece and demonstrate sound transmission.

Phase II. The contractor will design and develop a complete system which will take the output of a sonar system or communications set and transmit the sound to the diver using the mouthpiece. Techniques will be developed to clue the diver to perceived sound direction via alternative means.

DUAL-USE COMMERCIALIZATION. The technology will be incorporated into diver-held sonar imaging systems and diver communications systems.

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2. "Chew On This: The Hearing Aid Attaches To Teeth." Engineering News Item in Design News, 13 June 1994 3. "Tiny Actuators." Technology Focus Item in Mechanical Engineering, June 1994, p. 32.

TOPIC: OSD95-011 TITLE:Integrated Model/Measurement Comparison Tools

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TECHNOLOGY: Software

OBJECTIVE: To develop commercial software tools that allow the generation of high-fidelity synthetic background measurements and their seamless intercomparison with analogous empirical observations. These tools should employ current Navy-developed interactive data visualization and analysis tools and high-fidelity synthetic scene simulation technologies.

DESCRIPTION: The Navy is chartered by the Ballistic Missile Defense Organization (BMDO) to assemble, manage, disseminate and support the analysis of measurements of terrestrial, atmospheric, and celestial backgrounds from BMDO-sponsored and related experiments. The ultimate utility in the Navy datasets resides in their ability to promote and enhance defense and dual-use civilian studies which might employ these data. Software tools to better exploit these datasets by closely linking their analysis and visualization with the output from scientific models will make this data exploitation more effective and will also have comparable utility in civilian and military remote sensing applications.

A software package is needed which combines the capability to generate high-fidelity synthetic measurements and easily contrast them with comparable or identical empirical measurements such as those in the Navy archive. The package should use state-of-the-science simulation technology like the Navy-developed Synthetic Scene Generation Model (SSGM) to produce the simulated data and take into account the effects of the observing platforms and sensor on the synthetic measurements. In addition the package should integrate this scene simulation technology with interactive data visualization and analysis tools such as the Navy-developed Visual Interface for Space and Terrestrial Analysis.

This resulting data simulation and analysis tool should integrate those components of the DoD-developed simulation and visual analysis technologies which are most applicable to the ultimate development of a commercial product. Currently, these tools run on Silicon Graphics, Inc. scientific workstations. A suitable negotiated agreement will have to be reached in the final phase of this project with respect to the ownership and licensing of the resulting software package.

PHASE I: Develop a detailed design for a proof-of-concept integrated analysis tool which leverages existing DoD simulation and visualization technologies and tools as identified above. This design should identify simulation and analysis functions, specify the interfaces between the components of an integrated tool, and generate sample strawman output products from the existing tools to help define the component interfaces and to quantify and refine the final system design.

PHASE II: Implement the detailed design developed in Phase I and produce a working proof-of-concept system. Demonstrate the proof-of-concept system on an appropriate dataset which has the potential for dual-use or commercial exploitation.

DUAL-USE COMMERCIALIZATION: Integrated packages to generate and seamlessly compare spacecraft and aircraft data collection products have wide applicability in commercial remote sensing for resource management, environmental studies, etc. Such an integrated tool will also have wide applications as well for civilian global change research and DoD surveillance and weapons system development programs.

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1. Heckathorn, Harry and Wieland, Frederick, "Physics-Based, High-Fidelity Simulation: Strategic Scene Generation Model", Proceedings of the 1993 Winter Simulation Conference (Evans, G.W., Mollaghasemi, M., Russell, E.C., and Biles, W.E., eds), Society for Computer Simulation, International, 1994, p. 989.
2. Dombroski, E.G., Snyder, W.A., and Heckathorn, H.M., "Metadata Management and the VISTA System", Proceedings of the Twenty-Seventh Annual Hawaii International Conference on System Sciences (Nunamaker, J.F., and Spague, R.F., eds.), IEEE Computer Society Press, 1994, p. 418.

TOPIC: OSD95-012 TITLE:Trivalent Chromium Conversion Coatings for Aluminum Alloys

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TECHNOLOGY: Materials and Structures

OBJECTIVE: Introduce Trivalent Chromium Treatment and develop practical approaches to facilitate acceptance.

DESCRIPTION: The Navy and other DoD/Military Services utilize chemical chromate conversion coatings, e.g., "Alodine", on aluminum to impart corrosion resistance and to serve as an effective base for paint. However, the chromates (hexevalent chromium form) are highly toxic and present a hazard to operations as well as an adverse impact on the environment. A process has been developed at Navy that utilizes a vastly less toxic trivalent form of chromium to serve as alternative to the chromate process. The trivalent chromium treatment of aluminum has proven highly promising in laboratory tests and is presently being evaluated at several air/fleet facilities for application to aircraft components. This process is considered a potentially viable alternative to chromate coatings used for a multitude of commercial and military end items.

PHASE I: Investigate the trivalent chromium process for its beneficial environmental/health aspects at the expense of a somewhat more complicated process with a somewhat lower corrosion resistance in comparison to chromate coatings.

PHASE II: Evaluate the trivalent chromium process on a commercial scale for actual items currently utilizing chromate conversion coatings. Develop optimized bath composition for applications to aluminum by brushing or spraying or for bulk treatment of small parts. Addition of surfactant is advisable.

DUAL-USE COMMERCIALIZATION: The trivalent chromium process could replace an estimated 25% of current commercial applications for chromate conversion coatings within 5 years after the Government requires such replacement for items procured. Both constituents, analysis methods and replenishment procedures must be developed.

REFERENCES:
1. "Trivalent Chromium Solutions for Applying Chemical Conversion Coatings to Aluminum Alloys or For Sealing Anodized Aluminum", F. Pearlstein and V.S. Agarwala, Plating and Surface Finishing, p. 50-55, July 1994.

TOPIC: OSD95-013 TITLE:Free-space Optical Interconnection Packaging Technology

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TECHNOLOGY: Electronic Devices

OBJECTIVE: To package existing components into a device for rugged, low-maintenance free-space optical interconnections of electro-optic elements. Devices should demonstrate free-space optical interconnections for future shipboard applications.

DESCRIPTION: The Navy is developing optical communication systems for ships of the future. An important element of these systems is a free-space optical interconnection device to connect, switch, relay, or modify optical signals from one optical device to another. To be practical, this device must be able to interconnect 256 or more parallel signals between its input and output stages. On a processing stage, the devices should have some processing to qualify as "smart pixel" devices (preferably switching with a fan-out of 2 or more). Many electro-optic elements have been developed which convert the optical interconnections to and from electronic signals. These elements are typically active sources (e.g., vertical cavity surface emitting laser arrays), modulators, and detectors. Multiple optical sources can be generated by a laser array or by a laser in combination with a lens and grating.

PHASE I: Demonstrate packaging in a device consisting of at least 64 parallel interconnections between stages.

PHASE II: Build an optical interconnection device for a selected shipboard application. Device should be rugged to Navy shock standards and should provide thermal management of heating. Several models should be provided for Navy laboratory testing.

DUAL-USE COMMERCIALIZATION: Optical interconnection devices must be provided for shipboard environmental tests. There will be information highway applications. Free space optical interconnections will be important in fiber optic communications, optical processing, and optical memory usage.

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1. F. B. McCormick, Free-Space Interconnection Techniques, Photonics in Switching Volume II Systems, edited by J.E. Midwinter, Academic Press, Inc., 1993, pp. 169-250.
2. J.L. Brubaker, et. al., "Optomechanics Of A Free Space Photonic Switch: The Components," SPIE Proceedings Vol. 1533, 1991.
3. K. Rastani, et.al., "Integration Of Planar Frenel Microlenses With Vertical-cavity Surface-emitting Laser Arrays," Optics Letters, June 1991, Vol. 16, No. 12, pp. 919-921.
4. A.A. Sawchuk, et. al., "Smart Pixel Optical Computing Architectures," Optical Computing Technical Digest, 1993 (Optical Society of America, Washington, D.C., 1993), Vol. 7, pp. 214-217.
5. F.B. McCormick, "Generation Of Large Spot Arrays From A Single Laser Beam By Multiple Imaging With Binary Phase Gratings," Optical Engineering, April 1989, Vol. 28, No. 4, pp. 229-304.

TOPIC: OSD95-014 TITLE:Compliant Substrates

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TECHNOLOGY: Electronic Devices

OBJECTIVE: Demonstrate compliant substrates for Wide Bandgap Semiconductor materials

DESCRIPTION: Recently compliant substrate technologies have been demonstrated such that lattice-matched substrates can be supplied for any mole fraction of Si:Ge or II-VI alloy semiconductors. These substrates are created by forcing the misfit dislocations down into a very thin compliant layer rather than permitting the defects to propagate upwards into the epitaxy overlayers. This technology is critical to the new class of wide bandgap semiconductors such as 3C SiC and the various III-N materials for which there are no native (homoepitaxial) substrates.

PHASE I: Demonstrate a compliant substrate technique to reduce defect density of 3C SiC, GaN, or AlN materials to less than 106/cm3.

PHASE II: Demonstrate compliant substrates capable of supporting epitaxial overlayers of 3C SiC, GaN, or AlN materials such that defect density is less than 2 x 104 / cm3.

DUAL-USE COMMERCIALIZATION: The applications enabled by high quality wide bandgap substrates are virtually limitless. Among these are visible and UV LEDs and lasers, higher power IR lasers and LEDs, much higher power microwave and millimeter wave solid state amplifiers, new class B, push-pull ultra linear, ultra efficient microwave and millimeter wave amplifiers, which are needed for satellites, microwave ovens, microwave relay stations, and cellular phones (Iridium project).

REFERENCES:
1. T. Chu, F. Santiago, M. Stumborg, & C. Huber "The Role Of Barium In The Heteroepitaxial Growth Of Insulators And Semiconductors On Silicon," Mat. Res. Soc. Symp. Proc., Vol 334, pp 501-6 (1994).
2. A. R. Powell, S.S. Iyer, F.K. LeGoues, "New Approach To The Growth Of Low Dislocation Relaxed Si:Ge Material", Applied Physics Lett., Vol 64, p. 1856 (1994).

TOPIC: OSD95-015 TITLE:High Temperature Package for Recently Developed Silicon Carbide

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TECHNOLOGY: Materials, Electronics

OBJECTIVE: Introduce Navy high temperature packaging technology and develop a commercial high temperature package for silicon carbide electronics.

DESCRIPTION: Recent development of silicon carbide electronics that operate at extreme high temperatures has produced the need for packages that can withstand hostile environments at high temperature. High temperature electronics packages today can withstand 150^{o} to 200^{o} C operation only for short periods of time. Silicon carbide electronics operate at such high temperature (above 500^{o} C) that even military specified packages undergo material oxidation, corrosion and structure changes which can cause failure of the package and device. The Navy at NAWCAD Indianapolis, has designed a custom high-temperature package that can withstand constant 500^{o} C operating temperatures. The Navy packages include a developed high-temperature (platinum, gold) bonding wire system for chip interconnections. Prototype packages have been manufacturing and will be subjected to environmental stress testing to ascertain high temperature durability. Testing should be completed by May 1995.

PHASE I: Transition the developed high temperature packaging technology to/at the silicon carbide manufacturer. Use the Navy-designed package as a prototype for developing a commercial high temperature package. Develop a package manufacturing process and manufacture prototype commercial packages.

PHASE II: Transition the developed prototype commercial package manufacturing process into a commercial process. The objective will be to manufacture a high temperature package capable of continuous use at 500^{o} C which will accompany silicon carbide devices intended for use in hostile environments.

DUAL-USE COMMERCIALIZATION: With the rapid development of SiC electronics, a true high temperature package (Navy design) will become available for use in hostile environments. Both military and industry would utilize the developed packages.

REFERENCES:
1. Transactions; Second International High Temperature Electronics Conference (HITEC), High Temperate Packaging Sessions, Omni Charlotte Hotel, June 5-10, 1994, Charlotte, N.C.

TOPIC: OSD95-016 TITLE:Elastomeric Composite Bumpers

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TECHNOLOGY: Materials and Structures

OBJECTIVE: To commercialize a highly damage tolerant, high energy absorbing elastomeric matrix composite ship bumper for use in both Naval and commercial shipping applications.

DESCRIPTION: The Navy is currently developing highly abrasion resistant and damage tolerant elastomeric matrix composites for use in a wide variety of applications. These materials have exhibited elastic deformations greater than 60% while maintaining significant structural properties. These materials systems have significant potential for use in impact applications such as bumpers for naval and commercial ships as well as moorings in shipyards and commercial marinas. Due to the tailorability of these materials, designs can be developed which are uniquely suited to energy dissipation from impacts of large vessels.

The Navy desires a small business to design and develop novel marine impact bumpers for dual-use military and commercial markets. This program will require materials characterization to develop necessary design data. Development of low cost processing for fabricating these bumper structures is also required in order to provide an appropriate alternative or for retrofitting onto existing structures.

PHASE I: Fabrication of structural configurations from the elastomeric matrix composites for characterization of mechanical and impact performance properties. Develop designs and low cost manufacturing concepts for these bumpers.

PHASE II: Design and fabricate large subscale test articles using at least two manufacturing processes such as filament winding, resin transfer molding, or pultrusion. Down select to one process for fabrication of a full scale test article to be tested by the customer.

DUAL-USE COMMERCIALIZATION: Impact bumpers are utilized in both commercial and military ports and marinas. In addition this technology has applicability in automotive bumpers, highway safety devices and machinery guards.

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1. Crane, Roger M. and Ratchliffe, Colin P., "Graphite/polyurethane Flexible Composites: Mechanical and Vibration Damping Properties", Survivability, Structures and Materials Directorate Research and Development Report, CARDIVNSWC-TR-601-93/02 August 1993, 57 p.
2. Crane, Roger M., Santiago, Armando L. and Ratchliffe, Colin P., "Structural and Damping Characteristics of a Flexible Composite Structure", submitted to International Symposium on Materials for Noise and Vibration Control, 1994 ASME Winter Annual Meeting, Nov. 6-11, 1994.
3. Fischer, Eugene and Crane, Roger M., "Load Bearing Connective Damper", U.S. Patent No. 4,954,377 4 September 1990.
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5. U.S. Patents 5,194,181; 5,232,639; and 5,190,624.

TOPIC: OSD95-017 TITLE:PAWS Off-Line Programming System

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TECHNOLOGY: Software

OBJECTIVE: To increase the productivity in the U.S. shipbuilding industry by infusing the shipyards with information technology which facilitates the link between design and robotics manufacturing. To help achieve this goal, the Off-line Programming Software (OLP) developed as part of the Programmable Automated Welding System (PAWS) Program will be transitioned for commercial use. This software, currently under development offers significant advantages to manufacturing operations employing robotics in small batch operations.

DESCRIPTION: The Navy shipbuilding industry and other DoD/Military Services have a need to employ robotics automation technology in small batch manufacturing operations. The desire to employ robotics results from the need for higher productivity and quality. However, to successfully integrate robotics into a small batch manufacturing environment, the efficient programming of the robotics system is essential. The PAWS-OLPS developed by the Navy addresses this need. This software efficiently interfaces with CAD and manufacturing process information to derive the necessary robotics operations for automated welding manufacturing. The architecture of this software easily allows extensions to other manufacturing processes.

However, the PAWS-OLPS currently requires a relatively high level of user expertise and capital investment for computer hardware. Consequently, its acceptance in general manufacturing operations may be limited. Additional links into the software infrastructure of U.S. shipyards taking advantage of emerging national standards are required. Therefore a development effort is proposed to address these constraints.

PHASE I: Create an automated interface with CAD systems to eliminate "process" decision making operations and allow the system to "batch" process CAD information.

PHASE II: Porting of PC-based solution for both the process planner and the simulation software for a low cost solution, implementing standards used with U.S. shipyards, customizing for specific needs of installation sites, and developing network support structure.

DUAL-USE COMMERCIALIZATION: The use of OLPS technology has immediate application in any small-batch robotics manufacturing operation. Both government contractors and commercial manufacturers can benefit from OLPS technology. Prime examples include, the ship building and aerospace industries where use of robotics automation technology has been identified as key technology.

REFERENCES:

1. Hemmerle, J., Terk, M., Gursoz, E.I., Prinz, F.B., and Doyle, T.E., "Next Generation Manufacturing Task Planner for Robotic Arc Welding", ISA Transactions of Artificial Intelligence for Engineering, Design and Manufacturing, (cd. S. Rubin), April 1992. Vol. 31, No. 2, pp. 97-114.

TOPIC: OSD95-018 TITLE:INTEGRATED SURFACE TREATMENT SYSTEM

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TECHNOLOGY: Processing, Materials

OBJECTIVE: To provide an extension to integrate the Plasma Spray CNC Workcell focussing on cost-effective repair and refurbishment.

DESCRIPTION: The Navy Manufacturing Science & Technology (MS&T) Program previously funded the development of an integrated Plasma Spray CNC Workcell for the repair and refurbishment of large cylindrical parts. This system fully integrated the several steps of workpiece preparation, thermal spray repair, remachining and inspection processes and was intended for use at Navy repair facilities. This system also included the development of certain software tools for efficient process planning. This prototype system met each of the design criteria, but due to budgetary restrictions has not been fielded. Following Navy MS&T dual use objectives, the approaches developed for this prototype system should be adapted to commercial use.

The prime consideration is one of economic viability. The prototype design emphasized quality of refurbishment and producibility. In a commercial environment, other considerations relating to acquisition and maintenance costs, programmability, and ease of use may be as important.

The workcell combines a DC powder plasma spray and CNC turning center and was designed specifically to process cylindrical components such as valve stems, pump and blower shafts, etc., to meet Navy standards and the capability of reducing the skill levels of the operator by providing computer based tools to guide the planning, setup, and execution of the series of processing steps in repairing and refurbishing these components. One of the first tasks should be to establish the commercial viability of this overall approach. Portions of the system development should be closely examined with regard to their ability to satisfy market needs.

PHASE I: Conduct an assessment of the market needs for an integrated surface treatment/repair & refurbishment system. Establish realistic performance, and cost goals for viable commercial versions of this system and determine the value of spin-off technologies including the stand-alone process planner. Define the areas for further development of the prototype to improve ease of use, productivity, and quality of repair and refurbishment. The specific requirements of machine cost, software reliability and ease of use must be examined. The extension thermal spray capabilities to HVOF (High Velocity Oxy-Fuel) and other surface treatment processes should be addressed as dictated by market considerations.

PHASE II: This phase would include the completion of the systems and software modifications to provide added ease of use, improved maintainability, and enhanced operator interfaces to guide the planning, setup, and execution of workcell functions and the software tools that will meet commercial market needs. This task will also seek to eliminate the use of the grit blasting process within the workcell. The grit option was needed to meet the Navy requirements, but is not the optimal solution. Alternative surface preparation approaches relying on diamond honing, or HVOF surfacing would provide better solutions.

DUAL-USE COMMERCIALIZATION: There are a number of viable commercial uses for this technology, but each needs to be tailored to the specific requirement of the process and must meet the economic limitations on cost of acquisition, maintainability, and ease of use. It is likely that this workcell technology can be applied to both retrofit and new equipment. The cost of the turning center is the most serious deterrent. Potential process applications include: the application of specialized coatings to large cylindrical sections; the coating and refurbishment of shafts and rolls for the paper, steel and aluminum processing industries; and the refurbishment of large rotating machinery shafts for power and energy systems.

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